

Tritium Dose Overestimates By CAP88-PC

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Introduction

The dose assessment software CAP88-PC may overestimate dose from tritium under some conditions, after seemingly minor changes are made to the input data. The overestimates can be traced to three key assumptions implicit in the software that may not be immediately apparent. The three assumptions are: (1) the contribution of home-grown food, (2) the distances at which food is produced, and (3) the number of people consuming locally produced food.

Background

Use of tritium at DOE facilities, such as Brookhaven National Laboratory, is an important issue (see Health Physics Society Newsletter, June 1997, "Secretary Peña Terminates Brookhaven Contract", in DOE News). Assessing the dose from tritium releases at DOE facilities is commonly done with the EPA-approved computer model CAP88-PC (Parks 1992), which stands for "Clean Air Act Assessment Package, 1988, for Personal Computers". CAP88-PC is widely used by EPA and DOE to demonstrate compliance with EPA standards for radionuclide emissions to air (40 CFR 61 Subpart H). CAP88-PC results compare favorably with measured off-site tritium concentrations (Simpkins, 1997) and other Gaussian dispersion models (Maheras, 1994).

To assess the dose from tritium releases with CAP88-PC, the user supplies the program with information on the annual release rate (Curies/year), data on local weather patterns, and the distribution of people around the site, using a circular grid with up to twenty radial distances, out to a maximum radius of 80 kilometers (50 miles) around the site. Because ingestion is an important pathway for tritium dose, the user also supplies data on nearby agricultural production, including produce, milk and beef cattle. The program uses this information to compute tritium concentrations in air and food, and intake rates to people from ingestion of food produced in the assessment area.

It is important to note here that CAP88-PC is programmed to grow food at all of the locations where people live in the assessment area; that is, the arrays of agricultural production use the same distances as those used to define the population grid. The program also checks to see if enough food is grown in the assessment area to support the population; if not, the program imports enough food to cover nutritional needs. Any imported food is assumed to contain no tritium. Imported food is an important consideration for large metropolitan areas.

While this kind of assessment may seem fairly straightforward, there are three assumptions built into the CAP88-PC model which may lead to an inadvertent overestimate of tritium dose. The first of these assumptions is the fraction of home-grown food.

Home-Grown Food

CAP88-PC allows the user to specify the fraction of food that is home-grown; including produce, milk and beef cattle. The user can also specify the fraction of food that is obtained from farms within the assessment area, as well as the fraction that is imported from outside the assessment area, which is assumed to be unaffected by releases of tritium. Food obtained from within the assessment area (but not home-grown) is taken as a weighted average of food grown at all distances supplied by the user for the population array, on the assumption that such food is randomly distributed by marketing.

Unfortunately, reliable data is usually not available for these food consumption patterns, and assumptions must be used instead. It is usually reasonable to assume that the home grown fraction is relatively small, and the food taken from the entire assessment area much larger. This assumption has the effect of minimizing tritium dose for people living close to a facility, but it also tends to raise dose for people living farther away, because it increases their consumption of food that is grown closer to the emission source than they live. One can also make the conservative assumption that all food is home-grown, to maximize the dose to people living close to the facility. While it is not possible to judge if this assumption is appropriate in the absence of reliable data, it is reasonable to believe that this will overestimate dose in most cases.

Distances Used For Agricultural Production

The second assumption that can lead to an overestimate of tritium dose is the distances at which food is produced around the facility. The CAP88-PC software is constrained by memory limitations to use only a total of twenty radial distances, which means that equally dividing the entire 80 kilometer (50 mile) radius assessment area will result in fairly coarse divisions, of about every 4 kilometers or so. This resolution does not give good information on the doses to particular individuals who may reside close to a facility, but who do not happen to live near one of the twenty distances that was used in the assessment. For example, assume that someone lives at 500 meters from the emission source, and the nearest distance that had been used was 1,000 meters. The best way to find doses for people very close in is to make the CAP88-PC calculations again, using the particular distances of interest. Unfortunately, since there is an upper limit of 20 distances that may be used in CAP88-PC, adding new distances closer in usually means having to take out distances farther away.

However, removing one of the outer distances often results in an overestimate of dose, even though nothing else was changed. This happens because, by reducing the distances you use for placing people around the facility, you are also reducing the distances used to grow food. By dropping distances that are farther away, and adding distances closer in,

you are forcing the program to grow food at distances that are closer to the emission source. If people around the site are in fact obtaining food which is produced at distances farther away, then the calculated tritium dose will be greater than that which actually occurs. This situation only affects assessments where the home-grown contribution to food is small, and the fraction of food taken from the assessment area is large. If one makes an assessment on the basis that all food is home-grown, then it makes no difference where other food is produced.

Population Effects

CAP88-PC can also overestimate tritium dose if one assumes that there are significantly less people living in the assessment area than there actually are. CAP88-PC has an option to make what is called an 'individual' assessment, in which the actual number of people living at each location is ignored, and the program is instructed to place only one person at each location. This is done for computational convenience for assessments where population data is not available. The other option is to do what is called a 'population' assessment, in which the user supplies a population array describing the actual number of individuals residing around the site.

If one does a tritium assessment as a 'population' assessment, and then again as an 'individual' assessment, the dose in the 'individual' assessment can be much larger than the dose calculated with the more realistic 'population' assessment. This is true in spite of the fact that the distances used in both assessments are identical, and nothing else is changed.

The reason for this is that in a 'population' assessment, you often have a situation where locally produced food, all of which contains some concentration of tritium, is not sufficient to meet the total nutritional demands of the population. In that case, the program assumes that additional food is imported from outside the assessment area. The imported food is assumed to be free of tritium, and is distributed equally to everyone. This lowers total tritium consumption for each person to more realistic levels.

On the other hand, an 'individual' assessment does not consider the fact that there is actually not enough locally produced food (containing some concentration of tritium) to go around. The program will then make calculations on the basis that people can obtain all of their food locally, when the fact is that the large population will not allow locally produced food to feed everyone in the area. With no realistic upper limits on the consumption of locally produced food, CAP88-PC will overestimate the dose.

References

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